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Towards a conversion factor for soil microbial phosphorus

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ABSTRACT

The available methods of microbial phosphorus (P) analysis do not allow full cell lysis during fumigation and complete P extraction. Consequently, a correction of microbial P (P_{mic}) extraction efficiency (Kp factor) is always necessary. Here we evaluated possible under- or overestimation of microbial P by comparing the direct determination of Kp for various soils with the Kp values obtained from the literature.

We determined a soil-specific Kp value for Cambisol by coupling ^{33}P labeling, anion exchange membranes (AEM) water extraction and liquid fumigation with $CHCl_3$. The measured Kp for the Cambisol (0.69) was much higher than the Kp commonly used in the literature over the last 35 years (0.4). Experimentally measured Kp avoided overestimation of microbial P by more than 1.7 times. Therefore, a soil-specific Kp correction of extractability is a prerequisite for microbial P analysis.

To improve P_{mic} accuracy without direct Kp determination, we conducted stepwise regression analysis between soil-specific Kp values from the literature and soil parameters. The Kp increased linearly with decreasing total P. An exponential increase of Kp with decreasing organic C (R^2 = 0.45–0.76) revealed a threshold of 10 g C_{org} kg^{-1}. Combining three soil parameters in multiple regression – Kp = 0.76–0.007*C_{org} - 0.56*P_{tot} + 0.004*Clay – enables an excellent Kp prediction (R^2 = 0.99).

We conclude that the Kp value of 0.4 commonly used for estimating microbial biomass P cannot be accepted as a constant. Thus, in the absence of soil-specific Kp, we recommend using the regression models considering the basic soil properties.

1. Introduction

The soil microbial P pool (P_{mic}) plays a very important role in P cycling and is highly dynamic. Microbial P serves as both a P source for plants via turnover and mineralization of organic P, and as a P stock by immobilizing inorganic labile P. P_{mic} changes significantly in response to environmental alterations, e.g. drying-rewetting and freezing-thawing [1]. Overall, the soil P cycle is mainly controlled by microbial activity [2]. Globally, P_{mic} averages 8% of the total P, increasing from 1.6% in agricultural soils (high total P, but low microbial biomass) to 15% in soils of shrub ecosystems [3]. In forest soils, however, the P_{mic} can exceed 25% of total P and reaches about 80% of the organic P pool [4]. This calls for reliable P_{mic} measurements to evaluate the P cycle, especially in forest soils.

To date, no standardized methods of P_{mic} analysis – such as those for microbial C and N [5] – are available. Consequently, the global storage and local importance of P_{mic} has not been estimated yet due to the absence of sufficient and reliable data [3]. The determination of P_{mic} mostly follows the protocols using either gaseous chloroform fumigation [6,7] or liquid fumigation in the presence of anion-exchange resin membranes [8]. Both these approaches of P_{mic} determination, however, do not ensure: 1) full cell lysis, 2) complete extraction of microbial cell components from soil, and 3) the determination of the portion of phosphate released from microbial cells but precipitated on sesquioxides, with Ca^{2+} and Mg^{2+} or absorbed by organic matter [9–11]. Therefore, a substantial portion of microbial P bound in the cell materials remains non-extracted and will not be analyzed. This calls for a factor to convert extracted P to total microbial biomass P for correct P_{mic} estimation in soil [12].

For the last 35 years the conversion factor (Kp) 0.4 proposed by Brookes et al. [6] has been commonly used as a constant value. To date, the Kp factors were estimated either 1) based on commercially available lyophilised cells [6], or 2) by adding fungal and bacterial cultures to soil suspensions [13,14] using ^{32}P as a tracer of added P. These Kp's

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